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No. 770.

EFFECT OF DEPTH UPON ARTIFICIAL WATER-WAYS.

By THOMAS C. CLARKE, M. Am. Soc. C. E.

PRESENTED OCTOBER 16TH, 1895.

WITH DISCUSSION.

In examining the question of deep waterways between the lakes of this country and the ocean, the author has collected some facts of a general engineering interest, which he now presents to the Society. The question of first cost, the interest on which is represented by tolls, will be disregarded, and the inquiries will be confined to ascertaining the cost of transportation alone, taking the case of the Upper Lakes and Erie Canal between Chicago and New York as an example.

To ascertain the cost of transportation on this system these data are necessary:

First.—The number of trips which steamers and barges can make during the season of navigation. This depends upon the possible speed in artificial waterways. The number of trips per season also depends upon some other matters which do not affect this discussion; such as the number and character of the locks, the length of detention in port, etc.

Second.—The yearly cost of operating and maintaining large steamers, also of steam-towed barges.

Third.—The receipts per trip must be equal to the amount of annual expenses divided by the number of trips, to prevent loss. For the sake of comparison the amount of receipts per trip will be equally divided between the receipts from grain going east, and merchandise going west. The cost of carrying grain will be ascertained by multiplying the number of bushels carried per trip by a rate which will make up a half of the expenses per trip. Such rates will always be a little less than the actual rates, as shippers must provide for the contingencies of light cargoes. As the rule is equally applied to all the conditions of depth, the comparison will be a fair one.

Transportation between Lakes Superior, Michigan, and Erie costs less now than transportation by long ocean voyages, as the vessels have full cargoes both ways of grain, coal, ore, lumber and merchandise. They do a local business in addition to the through business, which is not possible on the ocean. Hence, people say, "If we could only get a ship canal so that lake vessels could go to New York without breaking bulk, the economy of transportation would be extended nearly 500 miles farther." It really means not only a ship canal, but a ship canal of such dimensions that the expensive ship shall not be detained too long while passing through it.

The conditions will now be examined. All of these are known except that of the depth of water under the keel of the ship, necessary to enable her to move at the required speed. If the question were simply one of resistance it could be solved mathematically, but there are other things to take into account. The Suez Canal when opened was 27 ft. deep, and vessels loaded to 25 ft. draft are able to pass through at the rate of 4½ miles an hour. If they try to move faster, the currents of water passing under their bottoms to replace that driven away by the screw, cause them to lose steerage way, and the ship takes a shear, runs her nose into the bank and stops not only herself, but other vessels. Greater width would help. The Suez Canal is now being dredged 5 ft. deeper and widened. It is hoped that speed can be increased to 6 or 7 miles an hour when the canal is deepened to 32.5 ft.

As a type of a lake freighter, the new steamer *Victory* will be taken. She is 380 ft. long by 48 ft. beam, and carries a cargo of 4 000 net tons

at 14 ft. draft; 5 000 tons at 16 ft., 6 000 tons at 18 ft., and 7 000 tons at 20 ft. Her economical rate of speed on the Lakes in deep water is 13 miles an hour.

The depth of lake harbors now contemplated by the United States Government is 20 ft. No port but South Chicago has 18 ft., the rest having not much over 16 ft.

Half an hour will be allowed for lockages in a ship canal, and the same for a fleet of barges. Thirteen days will be assumed as the time of detention in port in all cases. This time seems long, but is necessary in order to do a local business and get full cargoes. Better organization and machinery for handling freight would shorten this time.

Ship Canals.

I.—Erie Canal deepened to 18 ft. to admit steamers carrying 5 000 tons on 16 ft. draft. Distance: Chicago to Buffalo, by Lakes, 870 miles; Hudson River, 143 miles; total, 1 013 miles. At 13 miles an hour; time, 78 hours. Canal, 350 miles; speed per hour, 4 miles; time, 87.5 hours. Lockages, 72 reduced to 50, at one-half hour each, 25 hours. Total time in motion, 190½ hours. Round trip, 381 hours, or 16 days. Time in port, 13 days. Total round trip, 29 days, or seven trips per season of seven months.

Estimated Expenses.—210 days at $250	$52 500
Insurance and other expenses	43 950
Interest, 10% on cost, $200 000	20 000
	$116 450

Estimated Receipts per Trip.—One-seventh of $116 450 is $16 635, half of which is $8 318. The ship carries 5 000 tons on 16-ft. draft, equal to 166 500 bushels of wheat, the rate on which would be 5 cents; this would be $8 325 on 166 500 bushels.

II.—Erie Canal deepened to 25 ft., to admit steamers carrying 7 000 tons burden. Speed increased on canal possibly to 7 miles an hour. Distances: Lakes and rivers, 1 013 miles, at 13 miles an hour, 78 hours. Canal, 350 miles; at 7 miles an hour, 50 hours. Lockages, 25 hours. Total, 153 hours; round trip, 13 days. Time in port, 13 days, or 26 days, eight trips per season.

Estimated Expenses.—Allowing for extra coal, $120 000.

Estimated Receipts per Trip Going East.—One-eighth of $120 000 is $15 000, and one-half of that is $7 500. Ship carries 7 000 tons or

233 000 bushels, which, at 3.22 cents per bushel, makes $7 500, Chicago to New York.

BARGE CANALS.

Cost by Lakes to Buffalo and by present Erie Canal, 7 ft. deep.

III.—The present cost of conveying grain from Chicago to Buffalo is	1.25 cents.
Elevating and trimming cargo at Buffalo	1.15 "
Canal to New York	2.33 "
Chicago to New York	4.73 "

Actual rates from 4¾ to 7 cents.

IV.—Cost by Lakes to Buffalo and by Erie Canal deepened to 9 ft. Fleets of one tug and five steel barges loaded to 7½ ft. draft. Cargo, 1 500 tons.

Erie Canal, 350 miles. Speed, in motion, 4 miles an hour. Time, 87½ hours. Lockages, all locks lengthened for two boats, 15½ hours. Hudson River, 143 miles; speed, 6 miles an hour; time, 24 hours. Time in motion, 127 hours. Round trip, 254 hours, or 10.6 days; time in port, 12 days; total, 22.6 days round trip. Number of trips in 210 days, nine.

Estimated Expenses.—210 days, at $30	$6 300
Insurance and other expenses	7 700
Interest on cost, 10% on $40 000	4 000
Total expenses	$18 000

Estimated Receipts.—Full cargoes grain going east, 50 000 bushels at 2 cents is $1 000; going west, 1 000 tons at $1, $1 000. Total, $2 000 by nine trips, is $18 000. Total cost of conveying wheat from Chicago to New York *via* Buffalo and Erie Canal, when deepened to 9 ft., is:

Chicago to Buffalo		1.25 cents.
Elevating	.875 cent.	
Trimming	.275 "	1.15 "
Transportation (canal)		2.00 "
		4.40 cents.

An examination of the cost in the third and fourth cases shows that one of the heaviest charges is the 1.15 cents per bushel due to transshipment. Hence the loud cry for ship canals.

V.—Is it not possible that less expensive machinery can do the business on lake and canal? If the insurance companies will insure

a fleet of five steel barges 90 x 17½ ft. and loaded to 6 ft., from Buffalo to Cleveland, 174 miles, would they not insure a fleet of four steel barges 180 x 17½ ft., loaded to 7½ ft. draft, from Buffalo to Chicago? Such a fleet could pass the Erie Canal deepened to 9 ft. and with its few short locks lengthened.

The time would be as follows: Lakes and river, 1 013 miles at 6 miles an hour, 169 hours; canal, 350 miles at 4 miles an hour, 87.5 hours; lockages, 15.5 hours; total in motion, 272 hours × 2 = 544 hours or 23 days. Time in port, 13 days, or 36 days per round trip, allowing six round trips per season.

Expenses calculated on same basis as before, estimated at $24 000, to cover larger mileage and more coal used.

Estimated Receipts.—One-sixth of $24 000 is $4 000, and one-half is $2 000. They carry 2 400 tons, or 80 000 bushels, and the rate should be 2½ cents, to make $2 000.

It seems to the author that the proper thing is for the people of New York to vote for the 9-ft. enlargement; and the fleets of barges running on both Lakes and canal must follow. The profit would be so great that a very high rate of insurance could be paid.

SUMMARY OF COST OF TRANSPORTATION, CHICAGO TO NEW YORK.

I.	Ship canal 18 ft. deep, no transshipment.....	5 cents.
II.	" 25 " " "	3.22 "
III.	Barge canal and Lakes, 7 ft. deep, including transshipment.....	4.73 "
IV.	Barge canal and Lakes 9 ft. deep, including transshipment	4.40 "
V.	Barge canal and Lakes, no transshipment.....	2.5 "

The object of this paper, besides the usual one of exciting friendly discussion, is to call the attention of the profession to what seems to be proved in the foregoing, that a ship canal ought to be not less than 25 ft. deep, if it be intended to pass large lake vessels; and that a slight enlargement of the Erie Canal may allow fleets of steel barges to run from New York to Chicago, and transport freight at less rates than large lake vessels could do in a 25-ft. ship canal, even if it were used free of tolls. If this be true, why are ship canals wanted? In the judgment of the author, there is but one such canal needed; a ship canal around Niagara Falls on our own territory, allowing upper lake vessels to reach Lake Ontario ports, and there transship by rail or canal to New York.

DISCUSSION.

Mr. North. EDWARD P. NORTH, M. Am. Soc. C. E.—While there probably will be substantial unanimity in the indorsement of that part of the paper which declares for a canal of not less than 25 ft. depth, if intended to pass lake vessels, it may be worth while to examine the strongly urged alternative—a canal of no greater width of locks than at present, with only 8 ft. on its mitre-sills and 9 ft. in its fairway. This canal, according to the present State Engineer, Mr. C. W. Adams, will allow an increase of tonnage from 250 to 300 tons per boat, a matter of one-fifth; but as all of the locks are to be so lengthened that they will chamber two boats, the theoretical increase of business to be done on the canal will not be from 3 144 144 to 3 772 973 tons, but to about 7 500 000 tons. This would be an increase of some 60% over the tonnage of 1880, the year of greatest traffic. But the same forces which have reduced the tonnage on the Erie Canal from 4 608 651 tons in 1880 to 3 144 144 in 1894 will doubtless continue in operation, and it is probably safe to predict that the canal enlarged as urged will not deliver 5 000 000 tons of western and local freight to the city of New York any two consecutive years.

The proposition is in effect to maintain a stricture 350 miles long between the 40 000 000 or 50 000 000 tons of lake transportation and the 60 000 000 or 70 000 000 tons of shipping that crosses the harbor and bay of New York—a narrow and inadequate channel, through which the 5 000-ton cargoes of lake vessels are to be dribbled in 300-ton lots to meet 10 000-ton sea carriers. Shippers are asked to be satisfied with locks that will chamber two boats; whereas, a canal that would pass the 25 000 000 tons naturally seeking interchange between the waters of the Hudson and Lake Erie would chamber 20 boats of the same size. At the Sixth International Inland Navigation Congress Mr. C. H. Stieltjes showed that boats of 6.5 ft. draft were allowed a speed of 9.3 miles per hour in the ship canals of Holland; and American shippers are asked to be satisfied with a possible maximum speed of 4 miles per hour.

The establishment and maintenance of such great frictional resistance to the interchange of commodities between the producing and consuming centers of this country is advocated, in part at least, by many in this State, for the sake of the charges that can be levied on the passing traffic, to judge from a sentence in the last report of the State Superintendent of Canals, which reads:

"It is clearly evident that the duty of the Legislature will be to provide the means for the construction of the largest possible canal, intended for the navigation of boats of such construction as will be able to navigate the inland waters of this State, discharging and receiving their cargoes at Buffalo and New York, or other intermediate points."

If that does not imply a continued burden on the production and consumption of the United States in favor of a few, the words quoted are misleading. The spirit that dictated that sentence recalls the early part of the seventeenth century, when Henry IV found it necessary to forbid the clergy of France tolling the water-borne provisions *en route* to Paris. It is further opposed to any adequate conception of the true function of transportation. Mr. North.

The easily recognizable beneficence of transportation through ample channels, and with free competition, is a lower charge for the service; but as all costs for transportation must be taken in some ratio from the gains of both producer and consumer, any lowering of the cost of freightage is a direct contribution to the wealth of the community in which it occurs and enables that community to both draw its supplies and exchange its commodities over a larger area. It is the low, or comparatively low, cost of assembling the raw materials for manufacture or consumption, and distributing the finished products, that governs the locations of the great centers of manufacture and consumption.

Industrial history shows this to have been true all over the world. Holland easily took the primacy in manufacturing from the Italian cities while they were still financial centers through its use of the many mouths of the Rhine and the Maas, where they scatter themselves through the low country, and it held that primacy until England commenced improving its water-courses, and for some time afterward. This fact has been greatly obscured by the success of the British Navigation Act, passed in 1651. That act, doubtless aided by the attacks of Louis XIV, broke the maritime power of the Dutch within 50 years, and, "under God's good providence," has done more to extend the wealth and influence of the English-speaking people than all other legislative enactments.

But the English commenced the improvement of their roads as early as the reign of Henry VIII, when an act was passed for the better government of the religious houses and the mending of the highways. In the time of Elizabeth the first canal act was passed, but the great flood of canal bills did not come in until 1758, when Brindley commenced building canals. These canals immediately reduced the freight rates in England, more particularly in the manufacturing counties, to from one-third to one-fourth of what they had been previously, and they made England the manufacturing country that it has been since.

As pointed out by a prominent economist, it was the power to manufacture that enabled England to subsidize her allies on the Continent during the Napoleonic wars, because the gold they received from Britain came back to that country for manufactured goods. During the whole period of these wars, England increased in wealth. A like

Mr. North. effect was seen in the Dutch war for independence, as Philip had no other place to go for manufactured goods and munitions of war than Holland, and the very exertions which he made to conquer the Dutch added to their wealth, so that at the close of the war, Spain, although it drew on the wealth of America and the Indies, was impoverished, while the Dutch were rich. It was Brindley, with his coadjutors and successors, who sent Napoleon to Elba and Helena, rather than British soldiers and statesmen.

In 1830, when England left off canal building and commenced her railway construction, she had more miles of canal and improved waterways per given area than the United States now has of railroads. Her very rapid railway building up to 1847 confirmed her position as a manufacturing nation, and it was thought for years that that position was unassailable. A great American authority on iron manufacture said in 1870 that Great Britain was making more than half the iron of the world, and she would probably continue to do so. As a matter of fact, in 1870, the total production of iron was about 11 000 000 tons, and England made 54% of this; the United States made 15%, and Germany made 10.5 per cent. But in 1890 the production of the world was about 25 000 000 tons; the United States made 37%, Great Britain made 31%, and Germany made 18 per cent. He did not comprehend the influence of this then rapidly diminishing cost of transportation in the United States.

The rate of transportation in Great Britain for nearly fifty years has not been noticeably reduced. It is virtually as high now as it was in 1846. There is not in Great Britain a canal or a water course that is not in the hands of a railway company, a trust, or a private corporation; tolls are charged on every one, and very few have been enlarged or improved. It now costs about as much to get a bill through Parliament for a mile of railway as it costs in this country to build a mile of railroad. In the meantime, other countries have increased the size of their waterways, have made them free, and effected noticeable reductions in freight rates. Up to about 1870 the British had the advantage of the lowest internal freight rates; they held their primacy in manufacturing and controlled the price of finished products. To-day, no manufacturers pay as high a rate per ton-mile for assembling raw materials and distributing finished products as the British, and Americans pay the lowest rate. In spite of the former's ownership of between 60 and 70% of the world's effective ocean tonnage, they have given up the first place as manufacturers to the United States, and are now fighting with Germany, which is enlarging its waterways and building new canals, to retain the second place.

Apparently no English engineer has felt called on to say publicly what some have said to the speaker. If Great Britain is to continue to approximate to even its old position as the chief servant of the world,

it must nationalize, free and enlarge its canals. This, however, is held to be impossible while the power of capital invested in railways retains its influence in Parliament. Mr. North.

Mulhall puts the average railway freight rate in Great Britain at 2.8 cents per ton-mile. This, it should be noted, is a matter of estimate, as the railway managers of that country prefer not to make returns of their ton-mileage. There has been no appreciable change in British freight rates for nearly fifty years, for although a parliamentary commission lately reduced the posted rates, the classification was altered so that in some instances the rates were increased. In this country the average freight rate in 1865 was probably very near 4 cents per ton-mile, and now it is about 9 mills, or less than one-fourth of what it was.

Neither the ton-mileage nor the average freight rates for the whole country was ascertained until 1882. For that year and for subsequent years both have appeared in "Poor's Manual." They commence with 39 302 209 249 ton-miles carried at an average charge of 1.236 cents, and end with 82 289 400 498 ton-miles carried at an average charge of 0.851 cent (see Fig. 1). From 1865, however, "Poor's Manual" for some time has compiled the ton-mileages and rates of two groups of railroads, the Boston and Albany, the New York Central and Hudson River, the Erie, the Pennsylvania Central, the Pittsburg, Fort Wayne and Western, the Lake Shore, and the Michigan Central, designated on the diagram as the seven trunk lines; also the Illinois Central, the Chicago and Alton, the Chicago, Rock Island and Pacific, the Chicago, Burlington and Quincy, the Chicago and Northwestern, and the Chicago, Milwaukee and St. Paul, designated as the six western roads. The same diagram also contains the freight rates charged on all Massachusetts roads for 1871 and subsequent years, with the ton-mileage from 1872. These roads cover mileage outside of the commonwealth which is owned or leased by and forms parts of Massachusetts roads; the lines radiate into nearly all New England.

It will be noticed that in the case of both the trunk line and western groups the freight rates have been decidedly lower, and have fallen faster, than on the Massachusetts roads. Although, as "Poor's Manual" groups the roads of the country, the New England roads have 40% more traffic per mile than the average, the freight charge is 45% higher than the average. Massachusetts and New England education generally seems based on English ideas. It is said to be harder to get a charter for an opposition road in that section than in any other. Since about 1880, when the divergence in freight rates becomes noticeable, heavy manufacturing has been deserting Massachusetts and the country served by its roads. It is thought that lighter manufacturing may follow. Concurrently a demand for free raw material has risen. It is probable that free railroad building, with the consequent cheaper freights, would serve both that locality and the whole country better.

Mr. North. Accompanying this general fall in railroad rates and increase in traffic, there has been a wonderful development of the Lake commerce. The members of the Society are probably all aware of what Albert Fink, Past President Am. Soc. C. E., and Mr. G. R. Blanchard have said about the influence of water rates on railroad rates, and though some people hold that the railroad wars have been the compelling force in the reduction of water rates, there can be no doubt that as the rates by rail and water have decreased, the traffic has increased. This is shown in Fig. 2, where the traffic through the St. Mary's Falls Canal, leading out of Lake Superior, is the prominent feature. The traffic on the Erie Canal from the opening of the St. Mary's Falls Canal is also given, to which is added, as a matter of comparison, the traffic on the Suez Canal.

It will be immediately noticed that as an appliance for the service of the general public the Erie Canal, like the industrial position of Great Britain, is a decaying one. In 1880 the traffic was at its maximum in amount, and in 1894 it had fallen to 68% of that volume. For the ten years ending with 1869 the tolls collected by the State of New York on merchandise passing through canals averaged over $10 000 000 per year. This was possible when the freight trains on the New York Central Railroad averaged 25 to 30 cars carrying 8 tons each; but a canal that will only pass boats of from 250 to 300 tons burden has no excuse for existence when competing with locomotives that will haul over 1 000 tons from Buffalo to New York. Hence, even after all tolls were abolished, the value of the canal as a channel of distribution has been decreasing.

The Suez Canal, which was opened in the fall of 1869 in the service of a trade not unknown in the time of Solomon, led to a great development of traffic between Europe and Northern Africa on the one hand, and Asia, Australasia and Eastern Africa on the other, but it may have reached its maximum usefulness, and last year its traffic was only about 60% of that through the St. Mary's Falls Canal, built in the service of what was still a wilderness 25 years ago. The apparent arrested development of the Suez traffic is not due to the competition of cheaper routes (freighters through that canal claim not to receive as many shillings per ton of cargo now as they received pounds sterling when it was opened), but communities working for Asiatic wages do not seem able to acquire those wants which are necessary to the development of a large freight movement.

The St. Mary's Falls Canal was opened in 1855, with the lift divided by two locks with 11½ ft. on the mitre-sills. In 1881 a single-lift lock, with 16 ft. on the mitre-sills, was opened and the canal freed from tolls. Three years after, the draft of 89% of the traffic passing was greater than the depth of the old locks. Up to 1881 the development was fairly satisfactory; since then it has been phenomenal. Although the

Mr. North.

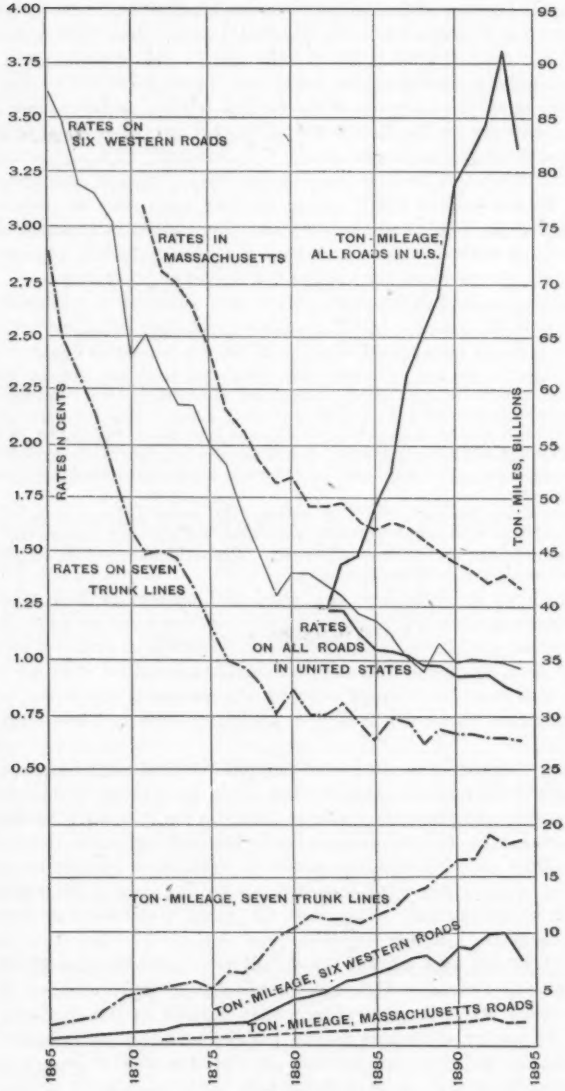

FIG. 1.

Mr. North. aggregate mileage of the Lakes, from the heads of Lakes Superior and Michigan to Buffalo, cannot be counted as more than 1 400 miles, and there are over 178 000 miles of railroads in this country, last year the ton-mileage through that canal was equal to 12.6% of the ton-mileage on all the railroads of the United States, and for some time the ton-mileage on the Lakes above Buffalo has been equal to about one-fourth of the railroad tonnage. Incidentally the populations of Buffalo, Cleveland, Detroit and Chicago have increased during twenty years at the rate of 209%, while for the same time at Cincinnati, Louisville, St. Louis and New Orleans, large cities in the same longitude but on water-courses which have not been materially improved or deepened, the increase has been at the rate of 40.2 per cent.

Writing in 1891 in favor of a 20-ft. lake channel, the late General O. M. Poe, M. Am. Soc. C. E., whose successful exertions for deep lake waterways have added so much to the wealth of this country, said: "During the season of 1890 over 9 000 000 tons of freight passed through the St. Mary's River, and more than 22 000 000 tons through the waterway between Lakes Huron and Erie. The increase in the navigable depth of channels on the Lakes from 9½ ft. in 1852 to 16 ft. in 1882 developed this commerce, and it is only reasonable to expect that a further increase of 4 ft. will be followed by a corresponding increase in shipping."

Continuing he says: "For nearly 30 years I have watched its increase, but neither I nor any one else within my knowledge has been able to expand at the same rate. The wildest expectations of one year seem absurdly tame the next."

This year it is claimed the wonderful figures of last year will be increased to 16 000 000 tons, an increase rendered possible by the commercial confidence in the future of lake freightage born of work on the 20-ft. channels. But any year's wild expectation of an increased traffic that must be strained through the proposed apertures in the enlarged Erie Canal, 8 x 18 ft. in cross-section, will seem hysterical the next.

The "Report on the Internal Commerce of the United States for the year 1891," contains an estimate that the saving to the public by the water transportation of the traffic on the Lakes for 1890 was $135 000 000, comparing lake freight charges with the railroad rates, which the competition on the Lakes have reduced. This is equivalent to a dividend of 66% on the total expenditures by the nation for river and harbor improvements. This was for some 9 000 000 tons carried at an average rate of 1.3 mills per ton-mile. Last year there were 13 000 000 tons carried for 1 mill per ton-mile, and 33 000 000 tons passed Detroit. Although in the April, 1891, number of the *Engineering Magazine*, and subsequently, figures of like import have been frequently presented to the public in technical journals and Government publications, persons are found who will gravely make and publish computations showing how much toll should be charged on a ship canal through this State.

Mr. North.

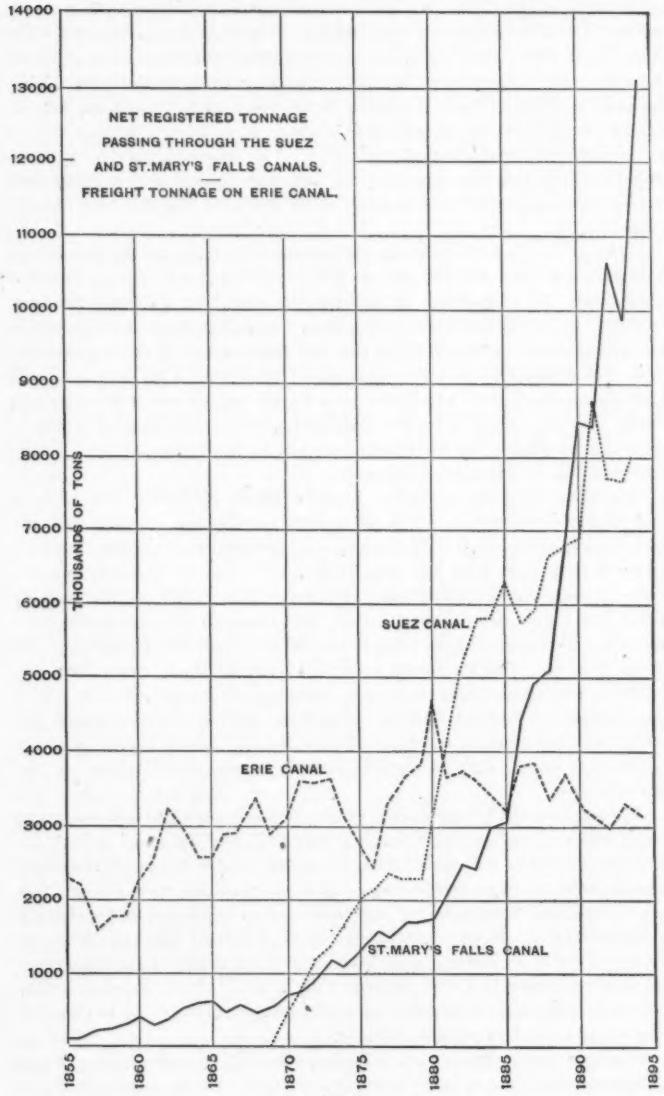

FIG. 2.

Mr. North. But the value of the deep waterway on the Lakes is not by any means confined to the money saved in freighting through their channels. The greatest good is derived from the industries they stimulate. E. S. Wheeler, M. Am. Soc. C. E., the engineer in direct charge of the canal at the foot of Lake Superior, estimates that fully half the freight carried would not sell at lake docks where it is landed for the cost of railroad freight from its point of origin. So that without the enlarged waterway the country would have lost the profits and employment engaged in the production of some 8 000 000 or 9 000 000 tons of merchandise.

Taking the item of iron ore, for instance, its value to the country is not limited by the $18 000 000 or $20 000 000 it is sold for on the lake docks, but by something in the neighborhood of $175 000 000, the probable value of the finished product. In addition to the interest in the securities of railroads built up and maintained by the transportation of this material and the supplies of those who manufacture it, all who are engaged in its production, or have occasion to use the finished product or any other thing the production and marketing of which is rendered profitable by the cheap freights on the Lakes, all are beneficiaries of those enlarged waterways.

Two other diagrams are shown in illustration of the effect of deepened and enlarged waterways. Fig. 3 shows the tonnage of ocean and inland vessels at the port of Montreal, with the increased depths obtained between that port and the sea. Fig. 3 also shows the railroad and river tonnage at Frankfort-on-the-Main. The traffic on this river, which had a governing depth of 3 ft., fell through the competition of railroads to about 10 000 tons, when it was decided to increase its depth to 8½ ft. The increased traffic in both of these cases that has followed deeper channels has been marked. It is hoped that these diagrams will, without further comment, show a direct relation between enlarged channels of interchange and decreased freight charges on the one hand, and increased production and distribution on the other.

A great deal of the opposition to improved waterways, not only here but in other countries, is through a fear that the value of money invested in railroads will be injured, the entire fall in freight rates being sometimes counted as lost income. If that reasoning were correct, the loss to railroad investors on the business of 1893 would be nearly $2 700 000 000 as compared with the prices of 1865. The net results to the people of this country have been that either supplies may be drawn and customers reached over an area with a radius four times as great, or for an equal area three-fourths of the freight money can be divided between the producer and consumer.

Probably the increased ton-mileage, which is thought to be greater in this country than in any other, is due partly to the augmented cir-

culation through the larger area, and partly to the saving in cost which creates a fund that is available for increased consumption. But it is doubtful if the railroads have lost much by the decrease in freight rates. Some investigations made in connection with a paper read at

Mr. North.

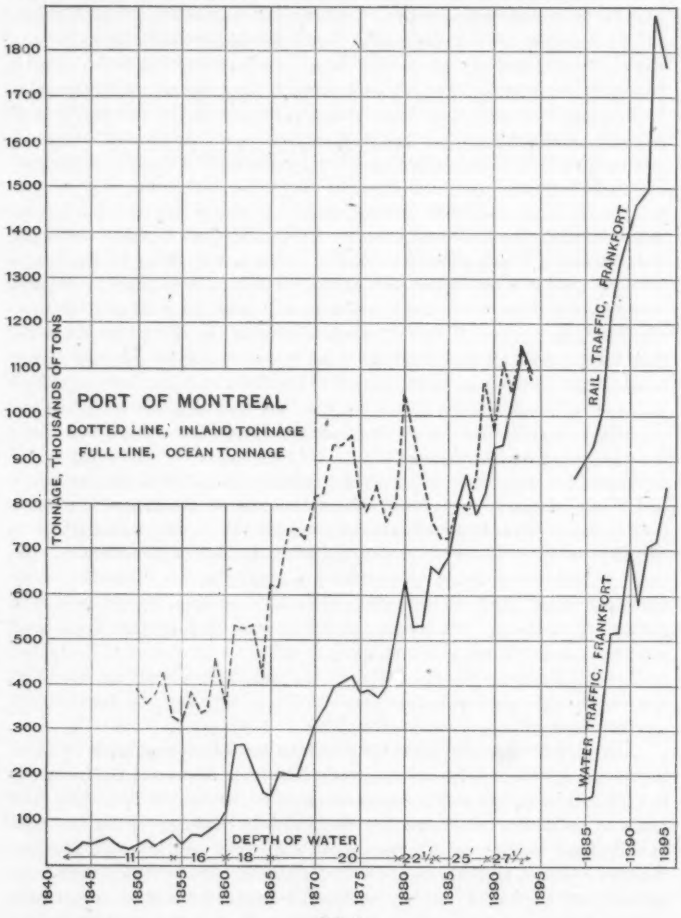

FIG. 3.

the Fifth (Paris) International Internal Navigation Congress showed that in the case of the seven trunk lines above referred to, the stocks were virtually at par on both July 1st, 1865, and 1890; that during the first-mentioned year, with a freight rate of 2.9 cents, the net income

Mr. North. was 29.207%, and for the last-mentioned year, with a freight rate of 0.68 cent, the net income was 31.95 per cent. Ten times as much traffic was handled at one-fourth of the cost per unit, with greater profit.

There are three propositions before the country : That the Erie Canal should be enlarged to a depth of 8 ft. on the mitre-sills ; that it should be made a ship canal ; that a ship canal should be built through Canadian territory and the produce of the West be forced to seek a market through the mouth of the St. Lawrence. The proposition in the paper to build a ship canal into Lake Ontario, so as to split the traffic with Canada, and prevent the population between Buffalo and Syracuse growing as that on the lake shore does, seems a modification of the last-mentioned plan.

The St. Lawrence plan seems attractive to certain minds. At an International Deep Waterways Convention held at Toronto last year, Mr. Smalley, a delegate, proclaimed : "It is our duty in equity, as well as in self-interest, to contribute towards deepening the channel down the St. Lawrence," and, claiming to speak for a large portion of the West, he said : "You will not find among the delegates from the Northwest any national prejudice that would stand in the way of our joining you in what is unquestionably the best and quickest way to get to the sea, because these two great English-speaking peoples," etc.—a formula generally used when any material interest of the United States is to be permanently injured.

There are many self-called broad-minded thinkers among us, without "any national prejudice" when looking at the interest of their own country, but strenuous vociferators for the equities and interests of other lands. The type is not unknown in the engineering profession; a member of it has said: "This is an engineering question in its broadest sense, and we should approach it, not as New Yorkers or even as Americans. A narrow patriotism may stop at the borders of our own country, but professionally," etc.

Let us examine the position of an engineer whose professional advice should govern the investment of money for the service and development of larger or smaller areas.

All know that from Chicago or Duluth to either New York or Montreal, it is substantially 1 500 miles. But from Montreal to the sea it is 1 000 miles, and from Thanksgiving Day to the first of May that 1 000 miles is ice-locked, so that any merchandise not cleared from the port of Montreal before or by December 1st must pay storage for five months, nor can any return goods be delivered during that period. At the port of New York, on the contrary, imports have free access and exports have free egress every day of the year, and storage is unnecessary.

Neglecting the broad and extrinsic patriotism of one who volunteers to turn out of his own country the many advantages accompany-

ing a great tide of commerce, it is submitted that professional advice to build the great avenue for the interchange of products between the interior of America and the sea coasts of the world to a five-months' wall of ice is not, on the whole, proposing to direct the great forces of nature to the service of mankind. Mr. North.

There is another consideration, not so patent as the ice in the St Lawrence, but more weighty. The main thoroughfare of any country should intervene between the great body of producers and their largest and best market. That for the American farmer is New York. That for the New Yorker is offered by the American farmer. In the census year 1890 the value of products manufactured in the city of New York was $777 222 721, and the value of goods manufactured in the six cities on the waters of New York Bay, viz., New York, Brooklyn, Long Island City, Hoboken, Jersey City and Newark, was $1 200 671 459. In the same fiscal year the total value of merchandise imported into the United States was $789 310 409. If all of the best authorities on political economy are not mistaken in their assertion that "commodities exchange for commodities," the markets of the world outside of the United States are worth 3% more than the market of the city of New York, and the consumption of the six cities bordering on the Bay of New York is worth 50% more to American farmers than the consumption of all foreign countries. The wages paid in manufacturing industries in the six cities above mentioned are equivalent to almost 42½% of the total value of the country's imports. These relations are shown in Fig. 4.

On the other hand, Montreal is an inconsiderable place of 216 000 inhabitants, with a total city revenue of nearly 80% of what the city of New York expends for sweeping its streets, and of about the same manufacturing importance as Schenectady. It is doubtful if all of Canada offers as good a market to our farmers as some of the numerous cities and towns on the line of the Erie Canal, and there are actually men who are led to believe that they are reaching for markets when they try to send the produce of the Northwest to sea *via* Montreal.

It is generally admitted that the cheaper rates of a large waterway, by stimulating the bordering industries, augment the traffic and profits of parallel railroads. The converse is also true. Large manufacturing industries require the services of railroads for the quick delivery of finished products and the necessary circulation of men engaged in such industries. Paralleling the line of the Erie Canal and jointly dependent on the industries and wealth built up by it for returns on the investment, one company has expended over $160 000 000; while in the part of this State which it is proposed to sidetrack by a canal into Lake Ontario, the line of the canal is crossed by competing roads every few miles. These adjuncts to the cheap transportation which an enlarged canal will offer make this part of the State an

Mr. North. ideal location for manufactories of all kinds, but the route by the St. Lawrence is virtually without such aids to industrial development.

It seemed to the speaker that the most advantageous route for a great ship canal connecting the commerce of the Lakes with that of the Atlantic, and serving, not only the largest number of consumers, but, to use the words of James Bryce, Esq., consumers "who allow themselves luxuries such as the masses enjoy in no other country," is substantially on the line laid down by Elnathan Sweet, M. Am. Soc. C. E., in his paper of June 10th, 1894, "The Radical Enlargement of the Artificial Waterway Between the Lakes and the Hudson River."

This line, passing as it must near the outlets of Cayuga and Seneca Lakes, would connect nearly 80 miles of deep-water navigation to the canal, and make Ithaca and Watkins, the towns at the heads of

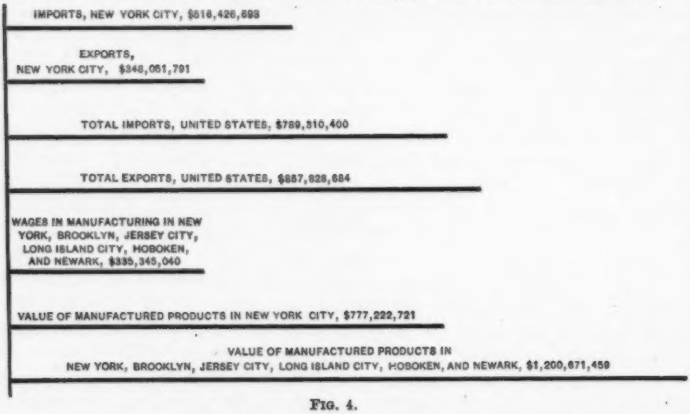
IMPORTS, NEW YORK CITY, $516,426,693
EXPORTS, NEW YORK CITY, $348,051,791
TOTAL IMPORTS, UNITED STATES, $789,310,400
TOTAL EXPORTS, UNITED STATES, $857,828,684
WAGES IN MANUFACTURING IN NEW YORK, BROOKLYN, JERSEY CITY, LONG ISLAND CITY, HOBOKEN, AND NEWARK, $335,345,040
VALUE OF MANUFACTURED PRODUCTS IN NEW YORK CITY, $777,222,721
VALUE OF MANUFACTURED PRODUCTS IN NEW YORK, BROOKLYN, JERSEY CITY, LONG ISLAND CITY, HOBOKEN, AND NEWARK, $1,200,671,459

FIG. 4.

these lakes, commercial ports of much importance, which, by the aid of a ship canal to Oswego, would dominate most of the trade of Lake Ontario and the upper St. Lawrence, instead of making the trade of all that region tributary to Montreal.

Reference to the causes which have made the city of New York the largest manufacturing city in the world, and incidentally draw 65% of the imports of the United States to this port, may not be out of place. It will be noticed that the position of the city is unique. It is situated at the mouth of a stream so commodious and grand that the *Great Eastern* could have ascended it for 120 miles, instead of at the head of navigation. The governing factor in New York's position and wealth is Long Island Sound. In addition to this, there is another navigable channel to the westward, the Kill von Kull. The report of the Chief of the United States Engineers for 1884 puts the tonnage con-

tributed to the harbor of New York through this channel at 16 500 000 tons. A later report says the tonnage of this channel is greater than that through the Narrows. Colonel W. M. Gillespie ascertained that the tonnage of the Hudson River was 18 500 000, of which 3 500 000 tons is contributed by the Erie and Champlain Canals. Mr. North.

When to the happy meeting of these natural channels of large capacity the tribute of the Erie Canal was added, there was no other place where the raw materials for manufacture could be assembled so cheaply, or from which the finished products could be more easily distributed. Hence all the railroads of the country pointed to or connected with it, and it became the seat of the largest production and consumption. Unless it becomes desirable to remodel the railroad system of this continent and reincur the expense necessary to the accommodation of nearly 3 000 000 people, the interests already centered in and about the city of New York demand such an ample waterway as shall now and in the future control the direction of commerce and augment the wealth and prosperity of this country, rather than that of a country which some hope to possess in the future.

CHAUNCEY N. DUTTON, Esq.—In discussing the project of a ship canal from the Great Lakes to the seaboard, the speaker did not propose to limit the range of thought to the narrow field, the grain carried by the Erie Canal. He stated that more than 9 000 000 tons of vegetable food are carried from the Lakes to the sea. The Erie Canal does not carry one-tenth of it. From 70 000 000 to 75 000 000 tons of through freight are carried on the routes paralleling the future continental highway, while the Erie Canal carries about one-thirtieth of it. The ship canal must be powerful enough, as a means of transportation, to compete with those carriers which have proved stronger than the Erie Canal. It will not be a competitor with the State canals; it will be a feeder to them, filling them up with local distributing business, which they can do cheaply and profitably. It may relieve them of a part of the through business, for which they are ill adapted, because it can do it cheaper, as can be proved by the author's own figures, and also by reliable data. Mr. Dutton.

The estimate in the paper, that in a vessel carrying 5 000 tons on 16 ft. the cost of transportation will be 5 cents per bushel, the speaker considered too high, in view of the present cost of conducting transportation in cargoes of 2 000 to 2 500 tons.

The estimate that in a vessel carrying 7 000 tons on 20 ft. draft the cost will be 3.22 cents per bushel, the speaker said was 2.5 times too high, as shown by an analysis of the author's figures, corrected in some particulars to agree with the present performance of steamships on the Lakes.

With regard to the third and fourth estimates, the speaker said that it is proposed to fit the Erie Canal locks with improved gates,

Mr. Dutton. which will add 12% to the tonnage of the barges using them. The draft in the locks is to be 8 ft., instead of 7.5 ft., and it can be deduced from the author's second estimate that wheat can be carried from Chicago to Buffalo for 0.75 cent instead of 1.25 cents, as he states. By making these corrections, he could have made a showing for the Erie Canal some 20% more favorable than he has. As a compensating error, however, he has assumed that barges can be towed at an average speed of 4 miles an hour in the Erie Canal.

The hypothetical barge, 180 ft. long, 17.2 ft. wide, 7.5 ft. draft and presumably about 11 ft. deep, could not have the same weight, cost, carrying capacity and expenses per foot of length as the real 90-ft. barge of equal width and draft, but her weight and cost would increase nearly as the square of her length, and, therefore, the hypothetical 180-ft. barge would weigh and cost nearly four times as much as the real 90-ft. barge, because, assuming the wave action in a seaway to be equal upon both, the weight would be nearly as the square of the length, as in beams. The 90-ft. barge weighs about 75 tons.

To settle this matter beyond controversy, the speaker obtained an approximate estimate of the weight, cost and carrying capacity of such a barge from one of the largest and most successful shipbuilding concerns in the country. Its chief engineer states that, "roughly speaking, the weight would be about 280 tons; the cost, $22 000, complete, ready for sea, and the carrying capacity about 360 tons. Such a barge would be of no service whatever if it were built." Such a barge never has been built, and if it were built it could not be towed singly around the short curves in the Erie Canal at the rate of 4 miles an hour; in fleets, not at all. Singly it might possibly be towed at the rate of 1 mile in 4 hours, by two tugs, one to pull her nose off and the other to pull her stern off at every curve.

That such a barge is not available for the lake traffic he believed clearly proved by the history of navigation on the Canadian canals. For nearly a generation there has been an open waterway with 9 ft. least draft. and only 54 locks, the smallest 45 × 220 ft., big enough for two of the hypothetical barges to lie in, and used by barges of much more advantageous proportions than the author assumes. The St. Lawrence barges never engaged in trade across Lake Ontario and through the Welland Canal. They are shut out of the lake traffic by steamers of 1 650 tons capacity, less than one-fourth of the size of the *Victory*, by vessels which cannot earn a living west of Port Colborne.

The tenacious hold of the barge idea is surprising in view of the facts. Had there been any such economies in barges as have been claimed, every shipyard on the Lakes would be building them; but, on the contrary, the one yard dedicated to barge construction is now building as many ships as barges.

The author gives the operating expenses of the *Victory* as $250 per

day, and her interest and other fixed expenses as $67 500 per year. The per diem ratio of these expenses he makes 1 to 210, basing it on a short season of lake navigation. He forgets that when the *Victory* can get to the sea, she will not go back to winter in the lakes. She will put in surface condensers, and engage in the coasting or foreign trade during the winter months, and the per diem ratio of her fixed expenses will shrink from 1 to 210 to 1 to 365, or from $321.43 to $184.93 per day, her total daily cost shrinking from $571.43 to $434.93, as the immediate result of making the ocean accessible to her. This alone reduces his estimate 24%, or from 3.22 cents to 2.45 cents per bushel. He figures on a route from Chicago to New York, 1 363 miles long, with 350 miles of canal and 50 locks—the Erie Canal route. A much better route will be *via* the St. Lawrence and Lake Champlain, 1 570 miles long from Chicago to New York, with at first only 90 miles of canal, and finally 75 miles, and only five locks. Mr. Dutton.

Applying his basis of speed to this route, 1 480 miles of open water at 13 miles per hour equals 113.85 hours, 90 miles of canal at 7 miles per hour equals 12.85 hours, and five locks at 24 minutes per lock equals 2 hours, a total of 128.7 hours, or 5 days 8 hours 42 minutes steaming time from Chicago to New York. The author estimates the time *via* the Erie route at 153 hours, 24 hours 18 minutes longer than the St. Lawrence route, or longer in the ratio of 100 to 24. Here is a further reduction of 16% in one item, the actual steaming time.

The author bases his estimate on the supposition that the ship would be tied up in port 13 days each trip. As a matter of fact, under favorable circumstances at Chicago or Duluth, she would discharge and receive her cargoes and clear the port within 12 hours of the time she entered. In the pamphlet, "The Great Lakes of North America," by the late George H. Ely, Assoc. Am. Soc. C. E., it will be seen that the ship *Manola* was in port an average of only 37 hours 36 minutes per trip during the entire season, her trips averaging 1 686 miles. This is on the Lakes. The author's assumption therefore means that when in New York the ship would tie up 11.5 or 12.5 days, as against 0.5 to 1.5 days in the lake ports. It was a violent wrench to the speaker's business instinct to assume any such thing. If New York does not provide good terminal facilities, other people will come and build them, as they built the elevated and cable roads, and many other things. But facilities for rapid loading and unloading now exist in New York for such cargoes as are in sufficient quantities to warrant them. It is a weekly occurrence that great ocean steamships are entered and cleared within three days; and it has been done within two days.

But suppose the terminal facilities not to exist, the speaker asked would a ship tie up here 11.5 or 12.5 days, when in that time she could carry her cargo to Europe, earning 4.75 to 6 cents a bushel; or could

Mr. Dutton. coast from Halifax to Galveston, or make a round trip to the West Indies and back, or run light to Chicago and Duluth and bring back another cargo. He believed that what the ship will actually do, on the author's basis of speed and cost, is this: She will steam 1 480 miles in open water in 113.85 hours; 90 miles of canal in 12.85 hours, and pass five locks in 2 hours. a total of 128.7 hours ; and will lose at the outside 37.6 hours in loading and unloading, a total per trip of 166.3 hours.

The author's basis makes her cost $434.93 per day, equal to $18.12 per hour, and the cost per trip of 166.3 hours between Chicago and New York would be $3 013.36, equal to 43 cents per ton, or to 1.29 cents per bushel, only a trifle more than the cost of breaking bulk at Buffalo, and 40% of the estimate in the paper. This is why the western shippers want to ship through and avoid breaking bulk, and why they demand ship canals. It is because it will save them 3.11 cents per bushel, or $1.161 per long ton over the cost of transportation in steel barges steam-towed *via* a future 9-ft. Erie Canal, according to the author's fourth estimate. This is on the supposition that the ship finds it more profitable to discharge at New York than to carry her cargo elsewhere, and finds a return cargo, which might be anthracite coal, sugar, building stone, bricks, ore, lumber, asphalt or package freight. If she found no cargo at New York, she could run light to Kingston for anthracite, or to Fishkill, Troy or Burlington for building stone, marble or package freight from New England; or to Lake Champlain for ore, or to Quebec for fish or iron sand, or to Oswego for anthracite, or to Buffalo or Cleveland for bituminous coal or coke. At the very worst, suppose she had to return light every other trip, she could run light to Chicago or Duluth for east-bound freight, in which case her account would stand as follows: East-bound trip and detentions, 166.3 hours; one-half of west-bound trip, 64.35 hours, a total of 230.65 hours, at $18.12 per hour, equal to $4 179 38, equivalent to 59.7 cents per ton, or to 1.6 cents per bushel, less than half of the author's estimate. This is the most unfavorable showing that can be made. New York is one of the three first-class ports of the American continent, and can provide return cargoes nine trips out of ten. Even were New York unable ever to provide a return cargo, and the port sealed so that the ship could not get out to find cargoes elsewhere, and were there no intermediate ports, and the east-bound freight had to bear the expenses of the round trip, the cost would only be 76.4 cents per ton, equal to 2.05 cents per bushel, less than two-thirds the author's estimate, and less than half the cost in steel barges *via* a 9-ft. Erie Canal.

The actual cost of operating ships of various sizes and of conducting transportation in them under various conditions was taken up by the speaker, who said that for the figures presented he was indebted

to the courtesy of correspondents familiar with the subject. As such statements might seriously affect important business interests, he merely presented conclusions in a summarized form. Mr. Dutton.

Attention was called to the published balance sheet of the Minnesota Steamship Company's ship *Manola* for the season 1890, which, so far as he knew, is the only authoritative statement of the kind ever published. The *Manola* is 292 ft. 5.5 ins. on the keel, 308 ft. 5.5 ins. over all, 40 ft. breadth, 24 ft. 6 ins. molded depth, 2 000 H. P., and can carry, fully laden, about 3 500 tons. In 1890 she was in commission 222 days, in port 47 days, steamed 175 days, made 30 trips of 1 686 miles each, equal to 50 584 miles or 227.5 miles per day, her speed being 11.85 miles laden, and 12.72 miles light, the average being 12.25 miles per hour. Her fuel consumption was 5 528 tons, worth $14 427.14. She burned per hour 209 lbs. when light, 226 lbs. when loaded, and averaged 218 lbs., equal to 1.5 ozs. per ton-mile. She carried 71 170.69 tons, equal to 2 295.816 tons per trip on 14.7 ft. to 14.9 ft. of water. She loaded in 7.5 hours, and unloaded in 12.5 hours. She earned $93 738.25 gross, $38 624.05 net; her expenses being $55 114.20, equal to 58.79% of her gross earnings.

Carrying 2 295.816 tons, less than one-third the capacity of the ship under consideration, she cost $248.26 per day, including insurance but not amortization, and earned $173.98 net per day, out of which she paid amortization and a very handsome profit to her owners. It will be observed that she cost daily only $1.74 less than the author's estimate of the running expenses of the *Victory;* and that the ratio of operating expenses to amortization and profits was as 100 to 70, and she was thought to do nobly. The author's assumed ratio is 100 to 129, a difference of 59 per cent.

The speaker next gave a summary statement of the actual cost of conducting transportation during the current season, up to October 1st, in a large fleet of lake steamships, which are a fair average of the large lake freighters. In the statement furnished to him, some of the calculations were based on gross tons and some on net tons, but all have been reduced to gross tons for better comparison with the statement of the *Manola*.

GREEN BAY PORTS TO LAKE ERIE PORTS.

Water.		Average cargo. Gross tons.	Cents.
15 ft. 4 ins.	Ore and return light.....	2 515.43	44.09
15 ft. 4 ins.	Ore down	2 546.36	36.28
	Coal up.....	1 869.54	29.56
	Average cargo.....	2 207.93 Average.	33.43

Mr. Dutton.

DULUTH TO LAKE ERIE PORTS.

Water.		Average cargo. Gross tons.		Cents.
14 ft. 2 ins.	Ore and return light.....	2 136.73		64.51
14 ft. 2 ins.	Ore down	2 009.17		44.45
	Coal back	1 934.21		35.08
	Average cargo.....	1 971.69	Average.	39.86

To the above must be added 4 cents per ton for painting, winter laying up and fitting out expenses, which would make the cost between Duluth and Lake Erie ports as follows on 14 ft. 2 ins. of water:

Vessel returning light, average cargo,			2 136.73	gross tons,		68.51	cents.
" carrying ore down,	"	"	2 009.17	"	"	48.85	"
" " coal back,	"	"	1 934.21	"	"	39.08	"
Average cargo			1 971.69	Cost...		43.86	"

Average cost of carrying 1 ton per round trip, 87.72 cents.

The statement of the *Manola* gives the cost per ton of freight carried an average of 1 686 miles as 77.4 cents, the draft being 14 ft. 7 ins. to 14 ft. 9 ins., and the cargo 2 296 tons. The vessels in this fleet average within 1 ft. of the length of the *Manola*, and are 3 ins. wider. The comparison of the figures, 77.4 cents per ton per trip by the *Manola*, and 87.72 cents per round trip by this fleet, is not fair to the fleet, because from the length of the *Manola's* voyage it is evident that she touched at intermediate ports, probably loading down as deep as she could in Lake Superior, and then running to Green Bay to complete her cargo. The speaker changed the figures for the fleet to make comparisons with the *Manola* more just. It cost the *Manola* 22.6 cents per ton to handle cargo. At the present time the charge for unloading is 15 cents per ton, and for trimming 2.5 cents, making a total of 17.5 cents.

If from the figures for the fleet 17½ cents are taken, and from the remainder 10.5% is deducted to compensate for being twice in port and loaded and unloaded as against once for the *Manola*, results are obtained which admit of an approximately correct comparison. This gives a cost of 62.85 cents per ton for a trip equal to twice the distance from Cleveland to Duluth, which would be approximately equal to the length of the *Manola's* trips. The average size of the fleet steamer is practically the same as that of the *Manola*, but the *Manola* had the advantage of 5 to 7 ins. of water, which enabled her to carry 325 tons additional cargo. Again correcting the figures for the fleet steamer, with this additional draft of water, she could have carried a cargo for 56.44 cents instead of 62.85 cents, the lack of from 5 to 7 ins. of water adding

6.41 cents to the cost of carrying cargoes a distance approximately 1 650 miles. Mr. Dutton.

The vessel's performance on this voyage may, without considerable error, be assumed as equal to her performance on a voyage from Duluth to New York, because if the detentions between Cleveland and Duluth be equated with those between Cleveland and New York, the equated distances, east and west, will be substantially equal. Therefore, the cost of conducting transportation between Duluth and New York in a vessel carrying 2 300 tons on 15 ft. of water would be 56.44 cents per long ton, or 1.51 cents per bushel. The fleet steamer's round trip performance, without corrections as above, is 87.72 cents per long ton, or 2.35 cents per bushel. To these must be added interest and amortization. The net earnings of the *Manola* per season of 222 days were 70% of her operating expenses. Had she been in commission 365 days and earned the same sum of money, the percentage would have been 42§. Adding this percentage to the figures given above, there results 2.15 cents corrected rate and 3.83 cents uncorrected for the remunerative freight rate in a vessel carrying 2 300 long tons on 15 ft. of water.

Through the courtesy of the executive officer of a great shipyard, the speaker was able to furnish some further light upon the effect of depth. The following are the data with reference to a ship which is to be 432 ft. over all, 412 ft. on the keel, 48 ft. beam and 28 ft. depth. It is to be a very heavily constructed, staunchly built hull, good not only for the present, but, if kept off the rocks and out of collisions, good for several generations.

DEAD WEIGHT CAPACITY IN NET TONS, INCLUDING 150 TONS OF FUEL.

	Net tons.		Net tons.
At 14 ft. 6 ins. draft.....	4 180	At 17 ft. 0 ins. draft.....	5 539
" 15 " 0 " "	4 450	" 17 " 6 " "	5 815
" 15 " 6 " "	4 272	" 18 " 0 " "	4 180
" 16 " 0 " "	4 990	" 18 " 6 " "	6 385
" 16 " 6 " "	5 264	" 19 " 0 " "	6 680

This ship is considerably larger than the *Victory*. If she were loaded to 20 ft., which is 1 ft. more than her builders have calculated upon, she would carry 7 265 tons. In view of the greater dimensions of this ship, it is doubtful if the *Victory* can carry 7 000 tons. The cost of the ship will be about $250 000. She will have 3 000 H. P. Her operating expenses will be about $175 per day, or $7 29 per hour.

Her fixed yearly expense will be about—

Amortization and interest at 12.5 per cent.....	$31 250
Repairs, painting, etc.....	2 750
Total.....	$34 000

Mr. Dutton. Allowing 15 days for laying up, this is at the rate of $97.14 per day or $4.05 per hour.

At the same rate of speed, etc., as heretofore assumed for the 7 000-ton ship, assuming this ship laden to 20 ft. and carrying 265 tons of fuel, her performance between Chicago and New York will be—

Assuming full return cargoes:

Conducting transportation.....	17.32	cents	per net ton...	0.52	cent per bushel.
Amortization, etc.....	9.62	"	" ...	0.289	"
Handling cargoes.....	17.5	"	" ...	0.525	"
Total.....	44.45	"	"	1.334	cents "

Assuming one-half return cargoes:

Conducting transportation.....	23.95	cents	per net ton equal	0.72	cent per bushel.
Amortization, etc..	13.33	"	"	0.4	"
Handling cargoes..	17.50	"	"	0.525	"
	54.75	"	"	1.645	"

Returning light:

Conducting transportation.....	30.725	cents	per net ton, equal	0.92	cent per bushel.
Amortization, etc.	17.06	"	"	0.51	"
Handling cargoes.	17.5	"	"	0.525	"
	65.285	"	"	1.955	"

The flat cost of transportation is given separately in order to show that in a life and death competition the big ship is invincible.

The effect of the depth of water upon the cost of carriage is very great in such ships. One inch means, at full draft, 49 tons, or 0.68%, and averages 46 tons, or 0.67 per cent. One foot means 8.4%, and 5 ft. 6 ins. mean 44.7 per cent. At 16 ft. draft the vessel will carry 4 990 tons, or, allowing 265 tons of coal, 4 725 tons of cargo.

The cost would be:

Assuming full return cargoes:

Conducting transportation	25.66	cents	per net ton, equal	0.77	cent per bushel.
Amortization, etc..	14.25	"	"	0.43	"
Handling cargoes..	17.5	"	"	0.525	"
	57.41	"	"	1.725	"

Mr. Dutton.

Assuming one-half return cargoes:

Conducting transportation.....	35.49	cents per net ton, equal	1.06	cents per bushel.
Amortization, etc..	19.75	" "	0.59	"
Handling cargoes..	17.50	" "	0.525	"
	72.74	" "	2.175	"

Returning light:

Conducting transportation.....	45.52	cents per net ton, equal	1.37	cents per bushel.
Amortization, etc..	25.28	" "	0.76	"
Handling cargoes..	17.50	" "	0.525	"
	88.30	" "	2.655	"

These figures include vessel insurance but not cargo insurance, which runs from 25 to 30 cents per $100 Chicago to Buffalo, and, of course, varies per ton proportionately to the value.

According to the paper, a ton of freight can be carried from Chicago to New York in a 7 000-ton ship for 43 cents; and according to the data here presented, for 44.45 cents. No other means of transportation can approach this for cheapness, and it is evident that if the ship canal be a private enterprise, remunerative tolls can be paid without raising freight costs to the point where competition would begin.

The economy of carriage will take effect, not only on grain, but also on all other commodities, effecting similar savings upon the present rail rates which have ruled this summer for car-load lots from Buffalo to New York, per long ton, as follows:

Upon articles in Class 1.....$7.28.

This class includes many kinds of package freights and small fruits.

Upon articles in Class 2.....$6.16.

This class includes wool, hops, canned goods, butter, eggs, dressed hogs, green hides, etc.

Upon articles in Class 3.....$5.04.

This class includes cheese, paints, and many kinds of boxed and barreled merchandise.

Upon articles in Class 4.....$3 36.

This class includes dry hides, baled rope, vegetables, heavy boxed and barreled goods which will stand rough treatment, and certain kinds of castings and metal goods.

Mr. Dutton.

Upon articles in Class 5.....$2.80

This class includes lumber, salt, hay, green fruit, grease, candles, glue, lard, molasses, stove castings, hollow ware, wall finish, peas, potatoes, seeds, etc.

Upon articles in Class 6.....$2.24

This class includes starch, sal soda, rice in boxes, green coffee in bags, beans, etc.

Upon flour, etc.....$1.12.

Upon live stock, as follows, per long ton:

Horses, $6.72; sheep and hogs, $3.92; cattle, $3.70.

The greatest percentage of saving in the cost of transportation will be on dressed meats, which now pay $10.08 per long ton from Chicago to New York, and are carried exclusively by rail. As this business is now conducted, the carcasses are first cooled for 30 days at Chicago and then shipped in refrigerator cars which are re-iced four or five times. When large steamships can ply between the two ports the freshly killed carcasses can be loaded into a ship having a cold storage plant and cooled while in transit, the cost of cooling and transportation being little, if any, greater than the cost of cooling alone at Chicago, because the expenses of the ship would be little, if any, greater per unit of capacity than those of the warehouse at Chicago.

The figures are from the latest official publications of the United States Government. There is a tendency in the articles to slip from one class into another on different roads, which makes exactness of statement impossible without a more searching analysis than the speaker had time to make. It must be borne in mind that over 95% of the freight moved pays these or higher rates, and that to attempt to limit the question to the small movement over the Erie Canal is to lose sight of the true significance to the West of a ship canal to the sea. But the western people do not get their minds side-tracked in any such way. They realize that economy in transportation is their only salvation; that a ship canal to the sea will pay them its entire cost in a single season.

CORRESPONDENCE.

Mr. Lamb.

RICHARD LAMB, Assoc. M. Am. Soc. C. E.—A canal-boat 98 ft. long, 17.5 ft. wide, and of 6 ft. draft, loaded to 240 tons, going at 1 mile per hour on 7 ft. depth of water with a canal prism of 450 sq. ft., meets a resistance of 173 lbs. The same boat, on 8 ft. depth of water, meets a resistance of 145 lbs. On 9 ft. of water the resistance would be about 120 lbs. The resistance increases as the square of the speed, and the power necessary to overcome the resistance as the cube of the speed. It will therefore be seen that on the Erie Canal, with its present depth of 7 ft., a boat loaded to 240 tons, going 4 miles per hour, meets a resistance of 2 768 lbs. and requires 29.44 H. P. to overcome this resistance. If the canal is deepened to 9 ft., the same loaded boat would meet a resistance of 1 920 lbs. and would require 20.36 H. P. to overcome the resistance, or a saving of about 30% in power. The same power that is necessary to propel this boat at 3.34 miles per hour on 7 ft. of water would propel it at 4 miles per hour on 9 ft. of water, a gain of 17% in speed, which at a speed of 4 miles per hour is a saving of about 30 hours on the round trip between Buffalo and Albany over the time at 3.34 miles per hour.

It is not practical to run boats on the Erie Canal much in excess of 4 miles per hour. At a 6-mile speed the water is expelled from below the bottom of the boat. Probably this is owing to the fact that the distance between the bottom of the boat and the bottom of the canal when the boat is not running is about 1 ft., or the boat has about 12 827 galls. of water under her. At 6 miles per hour, 1 166 galls. per second would have to go through 17.5 sq. ft. of sectional area if the boat had not buried any; but as a matter of fact, as the Erie Canal boats are built, practically square in the bow, the boat settles as the speed increases. Hence the sectional area under the boat would be much less than 17.5 sq. ft., making it impossible for such a quantity of water to pass under the boat in such a limited time; hence it takes the easier channels, namely on both sides, until there is no water under the boat at all. This theory is borne out by the fact that at the bows of a canal-boat going at 3 miles an hour an intumescence of the water is formed at least 1 ft. high above the level of the water on the side of the boat. This water, not being able to get under the boat, passes off on either side. In considering the available speed of a canal-boat, the swash has to be taken into account. In a report by John Bogart, M. Am. Soc. C. E., as State Engineer of New York, he tells of a small steam yacht that ran 6 miles per hour on the Erie Canal. They had to stop her from running other than slowly as she damaged the banks excessively. A canal-boat running much over 4 miles per hour, even though the Erie Canal was deepened to 9 ft., would not be able to navigate safely

Mr. Lamb. owing to the many bends and contracted places where steering would be exceedingly difficult and dangerous. As the canal is to-day only 7 ft. deep, a boat drawing 6 ft. cannot be steered at a speed to exceed 4.5 miles per hour, and at this speed only with difficulty and danger. The rudder needs the water to come up from the stern, and when the water practically all goes to the sides, the boat loses her steering way.

It is therefore evident that an average of 4 miles per hour is the proper speed to attain. The steam canal-boats average about 2.5 miles per hour and the horse boats about 1.75 miles per hour. By the writer's system of electric cableway, it is possible to average 4 miles per hour. With the current generated by water power, the cost of this electrical system per hour per mile is far less than either by steam or mules. The writer believes that the Erie Canal boat of the near future will be made of steel, with a spoon-shaped bow to raise rather than depress her when running fast, and will be 150 ft. long, 17.5 ft. to 20 ft. wide and 6 ft. draft. She will be made with a center-board, so that she will not shear when in a sea on the Lakes, and when in the canal the center-board will be raised. These boats will load at the lake ports and be towed in trains by powerful sea tugs to Buffalo; from there they will be towed by electric cableway motors to Albany, and thence by powerful river tugs to New York. All handling and elevator and warehouse charges at Buffalo will thus be saved. The writer believes from his knowledge of the difference in cost of shipping Pocahontas coal by ocean-towed barges over steam or sailing vessels, that if the present cost of shipping grain from Chicago to Buffalo is 1.25 cents per bushel, the train of steel barges can do it for 1.05 cents per bushel. He is also confident that a good profit can be made at barging from Buffalo to New York at 2 cents per bushel by electric haulage. By doing away with the Buffalo handling charges, the rate would become 3.05 cents per bushel from Chicago to New York. No railroad could compete with this rate except at a loss. The author's estimate of probable cost for this service, namely, 2.5 cents per bushel, is most likely accurate and conservative. As for the ship canal *via* Lake Ontario and Lake Champlain, as is proposed by the pneumatic canal-lock syndicate, its estimated cost would make a fixed charge of over 2 cents per bushel on all the freight that would be likely to go through it.

Again, any ship canal that uses the water of Lake Ontario with a view of getting an ocean outlet, would do as well if not better to go *via* the St. Lawrence River, as the steamship route from New York to Europe is northeastward to the Banks of Newfoundland, which track would not be far from the mouth of the St. Lawrence River. If a ship canal was built to New York it would be closed like the St. Lawrence River route with ice during the winter, at which time it would not be earning any money toward its fixed charges.

L. C. SABIN, Assoc. M. Am. Soc. C. E.—When a waterway is made up of two parts, one artificial and narrow, requiring limited speed, the other natural, placing no restrictions on the size or speed of the vessels, the selection of the boat best adapted to the traffic will be influenced by the relative lengths of the two parts and the extent of the restrictions necessitated by the artificial portion. This selection is usually a matter of evolution. It is of interest, however, to endeavor to arrive at the probable cost of transportation over a given route by comparing the conditions in a proposed channel with those existing in channels that are giving certain known results. In making such estimates of cost of transportation between Chicago and New York by the Great Lakes and the Erie Canal, the author reaches what appears to be a rather surprising conclusion. Doubts are frequently expressed as to whether the benefits expected to accrue from the construction of the ship canal from the Great Lakes to the sea would be sufficient to warrant the expenditure of so vast a sum as this project would require, but the proposition is now advanced that a barge canal 9 ft. deep will furnish cheaper transportation than a ship canal 25 ft. deep. Mr. Sabin.

Following the author's figures and assumptions, the cost of transportation between Chicago and New York by tows of four steel barges and one tug, and by the *Victory*, is as follows:

	Victory.	Steel barges.
Running time, round trip	5½ days.	12 days.
Delays in port	13 "	13 "
Total time, round trip	18.5 "	25 "
Round trips per season	11 "	8 "
Expenses "	$120 000	$24 000
" per round trip	11 000	3 000
" per single trip	5 500	1 500
Assumed draft	20 ft.	7.5 ft.
Cargo, tons	7 000	2 400
" bushels wheat	233 000	80 000
Rate on wheat, at per bushel	2.36 cents.	1.87 cents.

If these results represent the true state of affairs harbors may be allowed to silt up if they will; the supposed evolution in size of carriers has in truth been a retrogression, and modern lake freighters must give place to barges of 7.5 ft. draft.

For the consideration of this question there are reliable data concerning the lake traffic, and it would seem well to consult these data for a starting point. The author states that the "transportation between Lakes Superior, Michigan and Erie costs less now than transportation by long ocean voyages; as the vessels have full cargoes both ways of grain, coal, ore, lumber and merchandise." This last state-

Mr. Sabin. ment is not accurate as regards Lake Superior, and probably not so for Lake Michigan. In the past ten years the up-bound freight passing St. Mary's Falls Canal has amounted to but about 30% of the total freight. In other words, the west-bound freight has been less than half as much as the east-bound. The only bulk freight passing into Lake Superior in large quantities is coal. In 1894 the coal passing the canal amounted to only about one-third of the bulk freights, iron ore, grain and lumber, passing east.

It does not appear why "the number and character of the locks, the length of detention in port," etc., "do not affect this discussion." If modern freighters are considered, the assumption of a delay in port of thirteen days for each round trip seems quite unwarranted.

The *Victory* has been so far from spending thirteen days in port for each round trip, that she has made seven round trips from two harbors to Cleveland (or Chicago) in the past two months, or an average of less than nine days per round trip. She therefore went three single trips in 13.5 days instead of lying in port. Large lake freighters do not wait many days for a cargo, but however long they might wait, they could not all carry full cargoes both ways. It is thought that five days' delay in port will be ample allowance for boats receiving and discharging two (one partial) cargoes for each round trip, while 7.5 days might be allowed on the route from Chicago to New York, where partial intermediate cargoes might be taken.

As an approximate estimate of the running expenses of the *Victory*, and the larger size steel barges, the following is submitted:

	Victory. 400 x 48 ft. 16 ft. draft.		Tug and four steel barges, each 180 x 17.5 ft. 7.5 ft. draft.	
Men required per day	20 at $2 00	$40 00	20 at $1 25	$25 00
Subsistence per day	20 at 75	15 00	20 at 50	10 00
Coal, tons per day	30 at 2 50	75 00	10 at 2 50	25 00
Oil, waste, etc., per day		2 50		1 50
Towing charges per day		7 50		
Running expenses		$140 00		$61 50
Running expenses per season	210 at $140 00	$29 400 00	210 at $61 50	$12 900 00
Outfitting, painting, etc.		4 600 00		3 500 00
Insurance	3%	6 000 00	4%	3,200 00
Interest	10%	20 000 00	10%	8 000 00
Deterioration and loss	8%	16 000 00	8%	6 400 00
Total expenses per season		$76 000 00		$34 000 00

In the estimated expenses given in the paper the items are not sufficiently detailed to admit of comparison with the figures given above. In explanation of the large difference in the estimated expenses of run

ning the steel barges, attention may be called to the fact that the author's estimate of $30 per day running expenses would not pay the expenses of the tug alone if running on the Lakes, and the barges must each have at least three seamen aboard. For the sake of argument, it will be assumed that the barges will keep afloat 210 days a year. Mr. Sabin.

Taking the cost of transportation in the Erie Canal, by boats which ply the canal only, at the figures given in the paper, and applying the changes indicated above as to delays in port, probable cargoes and running expenses of lake boats, the following results are obtained:

I.—Ship canal, 18 ft. deep, 16 ft. draft. Steamer *Victory*, 5 000 tons. Total time, round trip, 21 days; 10 trips per season. Expenses per season, $76 000; per trip, $7 600.

Receipts—West, half cargo, 2 500 tons coal at 40 cents	$1 000	
East, full cargo, 5 000 tons wheat at $1 32	6 600	
		$7 600

Rate per bushel on wheat, 4 cents.

II.—Ship canal, 25 ft. deep, 20 ft. draft. Steamer *Victory*, 7 000 tons. Total time, round trip, 18 days; 12 trips per season. Expenses per season (extra coal, $4 000) $80 000; per trip, $6 650.

Receipts—West, 3 500 tons at 40 cents	$1 400	
East, 7 000 tons at 75 cents	5 250	
		$6 650

Rate per bushel on wheat, 2.25 cents.

III.—Present Erie Canal and Lakes.

Chicago to Buffalo, total time, 10.5 days. Round trips per season, 20 days.

	16-ft. Draft.	18-ft. Draft.
Expenses per season	$76 000	$80 000
" round trip	3 800	4 000
Receipts—West, half cargo coal at 40 cents	1 000	1 200
East, full cargo wheat	2 800	2 800
Rate per ton on wheat	56 cents.	47 cents.
Rate per bushel, Chicago to Buffalo	1.68 cents.	1.4 cents.
Elevating and trimming	1.15	1.15
Canal transportation (author)	2.33	2.33
Total cost, Chicago to New York, per bushel	5.16 cents.	4.88 cents.

Mr. Sabin.

IV.—Lakes to Buffalo and (90×17.5 ft.) Barges in Canal.

	In Lakes— 16-ft. draft.	18-ft. draft.
Chicago to Buffalo, same as III	1.68	1.4
Elevating and trimming	1.15	1.15
Canal transportation (author)	2.00	2.00
Total cost per bushel, Chicago to New York	4.83 cents	4.55 cents.

V.—Steel barges, 180×17.5 ft., Chicago to New York.

	Five days delay; half cargo coal west on Lakes.	7.5 days delay; half cargo mdse. on canal at 50 cents, half cargo coal on Lakes at 40 cents.
Total time, round trip	28.5	31.
Round trips per season	8	7
Expenses per round trip	$4 250	$4 860
Receipts—West	480	1 080
East	3 770	3 780
Rate per bushel on wheat, Chicago to New York	4.7 cents	4.7 cents.

Summarizing these results the following table is obtained:

Case.	Conditions.	Dollars per ton.	Cents per bushel.	Mills per ton-mile.
I.	Ship canal 18 ft. deep, allowing 16 ft. draft	1.32	4.00	1.00
II.	" " 25 " " " 20 " "	.75	2.25	0.55
III.	Barge canal 7 ft., and Lakes {Lakes, 16 ft. draft}	1.72	5.16	1.25
	{ " 18 " " }	1 63	4.88	1.20
IV.	Barge canal 9 ft., and Lakes {Lakes, 16 ft. draft}	1.61	4.83	1.18
	{ " 18 " " }	1.52	4.55	1.12
V.	Barge canal and Lakes, no transshipment	1.57	4.70	1.15

Comparing I and II, the advantage of the deeper canal is clearly shown, but if I and II are compared with V, it will be found that even an 18-ft channel is, according to the assumptions made by the writer, preferable to a barge canal, while the 25-ft. channel would effect a saving of nearly 2.5 cents per bushel over transportation by barges.

In conclusion it is of interest in passing to note the amount of tonnage required to pay interest on an investment of $150 000 000 in building a ship canal 25 ft. deep. Reckoning interest at 4%, the amount will be $6 000 000 per year and with a saving per ton of ($1.57—$0.75) 82 cents, the required freight tonnage would be about 7 500 000, or about one-half the amount that passes St. Mary's Falls Canal.

L. J. LE CONTE, M. Am. Soc. C. E.—The author's premises will hardly stand fair criticism, and, as a natural consequence, his final conclusions must be more or less subject to some modification. He seems to be in error in assuming that the estimated expenses in the two cases relating to ship canal will be $116 450 and $120 000 respectively. These estimates are plainly based on the supposition that the entire lake fleet of large vessels will always remain hibernated in the Lakes for five months in the year, as is now the case. On the contrary, so soon as the ship canal shall have been completed, this lake fleet will find it to its interest to migrate every winter to the Atlantic and engage in the coasting trade, where it will remain until the season on the Lakes opens again. It is clear that the second and third items under estimated expenses will be reduced practically to one-half the amounts stated in the paper. These cases will thus stand as follows: Mr. Le Conte.

I.—Eighteen-foot Erie ship canal. Total annual expenses on lake and canal traffic, $84 500; rate expressing actual cost of transportation, 3.67 cents per bushel.

II.—Twenty-five-foot Erie ship canal. Total annual expenses chargeable to lake and canal traffic, $87 000; rate expressing actual cost, 2.36 cents per bushel, which is something less than the author's barge-train rate, 2.5 cents per bushel.

The author's remarks relating to the introduction of a system of barge trains, 2 400 tons each, with a 9-ft. canal, are certainly wise and economical from every point of view, but it is evident that the ship canal will accommodate both ships and barge trains alike. Furthermore, the 25-ft. ship canal will admit of deep-draft barges and trains of much greater length, controlled by two tugboats, one at either end, so as to have complete command while going around the bends. As a result, greater speed and economy will certainly follow. The actual cost of transportation of grain by these large barge trains ought not to exceed 2.25 cents per bushel from Chicago to New York City.

LEWIS M. HAUPT, M. Am. Soc. C. E.—The question of cheaper transportation is always pertinent, and it is generally admitted that the open waterway furnishes the cheapest known medium. When it comes to restricted artificial channels, however, it is evident that a limit may be reached beyond which this law does not obtain. The author has shown in a practical and conclusive manner, as based upon his data, the relative importance of the barge canal and the apparent inutility of a ship canal between the Great Lakes and tidewater. But this case can hardly be used as a basis for a generalization since his figures are concrete. They serve to show, by inference at least, how many elements there are entering into the problem, and especially the importance of time, as measured by distance, lockage, demurrage and sectional area. He also shows an intimate relation between vessel and Mr. Haupt.

Mr. Haupt. channel, and raises the question as to whether the canal should be designed for the ship or the reverse. Here, again, arises a question of policy as to what size of waterway will yield the largest returns for the capital invested, which is a function of traffic, rates, geology, topography, labor, prices, plant, water supply and many other variables. But for a given traffic, at a paying rate, it will be a simple matter to determine the capital which may be safely invested, while the size of the trunk is more largely dependent upon water supply than on any other factor. This determined, the dimensions of locks and consequently of boats is in a measure fixed by the ratio between midship section and cross-section of the waterway necessary for appropriate speed without material damage or excessive power. The mere clearance under the keel is not so important as the width, for, in the writer's opinion, it is the inequality of pressure due to the lateral wave displacement in narrow channels, when the boat is not in the center, that causes shear.

The allowance made for port detentions in the calculations seems excessive, especially in view of the mechanical appliances for handling cargoes in bulk. The statement has been made that a lake propeller unloaded 3 000 tons at Erie, sailed to Ashtabula, and took on 1 800 tons, entering and clearing at both places in one day.

The present demands of lake commerce may be economically met by the 9-ft. barge navigation, but it should be remembered that the 14-ft. outlet through Canada will soon be completed, and if the commercial value of a waterway varies, according to Stephenson, as the cube of the depth, where will New York and the Atlantic seaboard come in, at this ratio of 9^3 to 14^3, or about 1 to 4?

Improvements in canal lifts and locks are now in order, and the prospects are that ere long the old gate of Leonardo di Vinci will be supplanted by the hydraulic lifts, which save both time and water, thus effecting still greater economy in the much needed improvements in internal navigation.

The author's statements hardly apply to the proposed coastwise canal system, nor are they intended to do so, since the vessels need not be constructed for a particular class of trade. These canals should be capable of passing any ordinary coaster, whether barge, brig, steamer or canal boat, at a fair rate of speed, and it is found that they will save at least 50% of the time on the round trip, and can be operated at a toll of less than half the present rates, and with benefits to all interests. Yet it is asserted that they are not needed, would not pay and will never be built.

Mr. Babcock. W. J. Babcock, Esq.*—The use of steel barges 180 ft. long, 17 ft. wide and with 7.5 ft. draft in a safe, large and uninterrupted traffic between Chicago and New York, is utterly impracticable from any commercial standpoint. The writer could guarantee to build a barge of these dimen-

*Manager of the Chicago Shipbuilding Company.

sions which would be entirely seaworthy and safe for the lake trip in all weathers, provided the towing vessel was either a large steamer or a powerful tug, and not more than two or three such barges were in one tow. If the power is to be applied in a similar barge, however, intended to go through the canal herself, then the experiment would be dangerous, as the draft of the tug is too little, and she could not make headway against a gale or sea with a tow behind her, and hardly by herself even. Such a barge, without power, would carry 17 000 bushels of wheat. There are boats on the lakes which carry ten times that amount even under the present conditions of navigation, and make their trips with almost the regularity of a passenger train. Ten barges would require four or five steamers to tow them, and the whole combination could not begin to transport the 170 000 bushels as cheaply as the one boat would do it. Mr. Babcock.

THOMAS T. JOHNSTON, Esq.*—The paper states that "the loud cry for ship canals" is because of the charge for transshipment of cargoes at Buffalo, but there are broader grounds for it. The ship canals at the mouth of Lake Superior are the most important in existence. It is within the memory of men still young when the canal and locks at St. Mary's Falls were of 9 ft. lift, two in number, with a depth of 12 ft. on the mitre-sills, an arrangement permitting a much more extensive commerce than would be possible in the Erie Canal enlarged to a depth of 9 ft. The usefulness of such an arrangement ceases when the tonnage exceeds about 5 000 000 tons. To-day there are two canals and three gigantic locks, those of recent construction having a depth of 21 ft. on the mitre-sills. The barrier to commerce at this place could not possibly be surmounted by a canal having even 14 ft. depth, and hence the loud cry for ship canals at this place. Mr. Johnston.

Before a ship canal could be constructed from the Great Lakes to the sea, great changes will take place in the commercial requirements of the people affected by the Great Lakes as a commercial artery. St. Louis, through the Chicago sanitary and ship canal, will stand in the same relation to the Great Lakes that Duluth does now, and 50 000 000 people west of Chicago will use foreign goods brought to them by way of the Lakes. The interchange of commodities east and west will be many times greater than at present, and individual products will be demanded in such large quantities that bulk shipments can be made. Small craft and canals for small craft cannot carry the traffic, and hence another loud cry for ship canals.

"The question of first cost, the interest on which is represented by tolls," is at the bottom of much opposition to ship canals. If the sentiment on which this matter of tolls rests is to prevail, the canals and locks at St. Mary's Falls should be destroyed at once, and no man should be allowed to drive his wagon from farm to market without

* Assistant Chief Engineer, Sanitary District of Chicago.

Mr. Johnston. making a cash payment for each trip. Existing transportation lines, aside from waterways, cannot possibly carry the commerce of the future, and must prosper in general as a consequence of the development of ship canals. The facilities for commerce offered by a water route, free from tolls, affords the basis for another loud cry for ship canals.

It is assumed in the paper that the *Victory* will be delayed in port $\frac{1}{2}\frac{3}{3}$ of the time she is in commission; that a ship canal from Buffalo to New York will have 50 locks; that 300 to 600-ton barges can be made suitable craft for lake navigation at an expense of $6 a day; and that it is proper to settle the merits of a ship canal on the basis of grain transportation alone. It is a matter of record that a large lake vessel has delivered a cargo of ore, been loaded with coal, and cleared within 15 hours. The ship canal from Buffalo may have less than a fourth of fifty locks. The harbor of Chicago could scarcely hold enough 600-ton boats to deliver and load the grain and flour shipments that are made now, to say nothing of the future. There are many cargoes to be carried between the Great Lakes and the seaboard which cannot be correlated to grain cargoes.

The assumptions on which the calculations in the paper are based may be easily paralleled with other equally logical assumptions leading to very different conclusions. The merits of a ship canal from Buffalo to New York may be logically discussed in the light of the performance of the best class of boats carrying through freight. At the present time every existing transportation facility between the Upper Lakes and the seaboard is, and for some time will be, taxed to its utmost capacity to handle commerce. The city of Chicago will this fall pay a tax of more than $2 000 000 on anthracite coal alone on account of this state of affairs.

Mr. Clarke. T. C. CLARKE, M. Am. Soc. C. E.—The object desired by the author "of exciting discussion," has certainly been attained. The conclusions of his paper were:

First.—"That a ship canal ought not to be less than 25 ft. deep, if it be intended to pass large lake vessels." None of those discussing the paper disagree with this.

Second.—"That a slight enlargement of the Erie Canal may allow fleets of steel barges to run from New York to Chicago, and transport freight at less rates than large lake vessels could do in a 25-ft. ship canal, even if it were (also) used free of tolls."

This statement is controverted, but the author fails to see that his arguments have been disapproved. The points attempted to be made are:

That the author has allowed too long a time for detention in port, and to disapprove this several writers show that the large lake steamers carrying coal to and ore from the upper lake ports to Chicago or

Cleveland only remain one day loading and unloading at each port. Mr. Clarke.
This fact was well known to the author, but it has nothing to do with the case of a ship canal through the State of New York. A large lake steamer gets her extraordinary economy of transport because she is moving back and forward all the time with full cargoes between two terminal ports. As she can get full cargoes she does not have to stop by the way.

Put this expensive machine on a canal, and all the conditions are changed. Her rate of speed cannot be over one-half and possibly not over one-third of that in deep water. New York and any single lake port could not afford full cargoes. She must stop at intermediate ports, both on the canal and on the Lakes, to take on and discharge cargo, or she will not have enough. Hence the author allowed 13 days for detentions in ports and still believes it a correct and conservative estimate.

As to the details of cost of operation while in motion, all those discussing the paper differ from each other as well as from the author, but he sees no reason to change his figures.

The ship canal would enable the lake fleet to go to the sea, and carry on transportation between Atlantic ports during the season of closed navigation on the Lakes, during such time as they would not have to be laid up for repairs. But the same advantage can be gained by fleets of steel barges, which could be used between Boston, New York and Philadelphia, as similar craft are now used. The author fails to see how his comparison is affected.

Mr. Babcock says that a barge 180 ft. long, 17 ft. wide and 7½ ft. deep is impracticable commercially, because a large steamer or powerful tug would be required on the Lakes, more powerful than that necessary on the canals. The author fails to see why one kind of tug could not be used on the Lakes, another on the canals.

But the author did not say that such large barges were absolutely necessary; he merely suggested (page 5, line 2) that it might be easier to get insurance upon them than upon smaller barges. This matter of insurance really is the key to the whole problem, and none of the objectors have denied its possibility. The company which built and tested steel barges on the canal and Lake to Cleveland do not seem to fear any trouble, as they have lately given an order for ten more barges and three tugs.

From the reports of the Inland Lloyds for 1895 it is possible to analyze the cause of disasters to the lake fleet. It is generally believed that storms and rough seas are the cause of the greater part, and that fleets of barges are not as seaworthy as larger steamers. This is true, but it is interesting to see how small a part of the actual losses are due to winds and waves.

Mr. Clarke. GRAND TOTAL OF LOSSES ON BOATS ON UPPER LAKES. FROM REPORTS OF INLAND LLOYDS IN 1895.

1.	Collisions	32%	$667 369
2.	Driven ashore	22%	476 914
3.	Disasters in the Sault Ste. Marie passage	14%	301 429
4.	Fire	16%	346 445
5.	Struck rocks	12%	211 985
6.	Unclassified	4%	70 777
		100%	$2 077 697

A very cursory inspection of this table shows that on items 3, 4 and 5 the chances of disaster would be less to tows of barges than to large steamers, while on item 1 it need be no greater. On item 2 only the barges would be more liable to disaster than the large single craft.